

☒	Description	: paged 1 to paged 15
☒	Claim(s)	: paged 4 to paged 20
☒	Drawing(s)	: paged 4 to paged 7/8
☐	Abstract	: paged 1 to paged 1
DATE OF RECEIPT		
MULTIPLE OPTICAL FIBER SPLICE		

Background of the Invention

1. Field of the Invention

5 The present invention generally relates to devices for optically connecting the ends of waveguides such as optical fibers, and more particularly to an article which splices a plurality of pairs of such optical fibers.

2. Description of the Prior Art

10 Splice devices for optical fibers are known in the art, but there is still a need for a quick and reliable method of splicing a plurality of fibers in a high density environment. Prior to the introduction of splice devices which join a plurality of optical fibers in a single splice body (discussed further below), this was accomplished by utilizing a plurality of single fiber (discrete) splice devices. This approach was very time consuming, however, and further resulted in a large volume of splice bodies which crowd junction boxes, or require specialized splice trays to keep the fibers organized.

Several systems have been devised to address the problem of multiple fiber splicing. One technique, mass fusion welding, requires that each fiber be placed in a groove of a rigid substrate having several such grooves. Best fit averaging is used to align the fiber pairs and an electric arc is created, melting the fiber tips and permanently fusing them together. The primary, and very significant, limitation of fusion splicing is the great expense of the fusion welders. Fusion welding is also time consuming, and precludes later fiber removal or repositioning.

Another common multiple splicing technique requires the use of adhesives, again with a substrate or tray that has a plurality of grooves therein. For example, in U.S. Patent No. 4,028,162, a plurality of



-2-

fibers are first aligned on a plastic substrate having fiber aligning grooves, and then a cover plate is applied over the fibers and the substrate, the cover plate having means to chemically adhere to the fiber and substrate.

5 Adhesives are also used in the optical fiber splice devices disclosed in U.S. Patent No. 4,029,390 and Japanese Patent Application (Kokai) No. 58-158621. The use of adhesives is generally undesirable since it adds another step to the splicing process, and may introduce
10 contaminants to the fiber interfaces. Splice devices using adhesives also require extensive polishing of the fiber end faces to achieve acceptable light transmission, and some adhesive splices further require the use of a vacuum unit to remove trapped air.

15 The '390 patent represents an improvement over earlier multiple splice devices in that it utilizes a foldable holder having a series of V-grooves on both sides of a central hinge region. The method of attaching the fibers to the holder, however, presents additional
20 problems not present in earlier splices. First of all, since adhesive is used to affix the fibers to the holder before splicing, the cleaving of the fibers becomes a critical step since the cleave length must be exact to avoid any offset of the fiber end faces, which would be
25 extremely detrimental to splice performance. Secondly, it is critical that the opposing V-grooves be exactly aligned, which is unlikely with the hinge depicted in the '390 patent; otherwise, there will be transverse fiber offset resulting in increased signal loss. Finally, the
30 '390 holder would not maintain the opposing plates perfectly parallel, which is necessary in order to optimize transverse alignment of the fiber pairs, and also affects fiber deformation.

Another problem with several of the foregoing
35 splicing devices is that they used rigid substrates to clamp the fibers. There are several disadvantages to the use of rigid substrates. First of all, it is generally





-3-

more difficult to form grooves in a rigid material, such as by etching, grinding or erosion, which increases manufacturing cost. Rigid substrates must also be handled more carefully since they are brittle and thus easily damaged. Most importantly, the use of a rigid substrate having grooves therein results in poor alignment of the fiber pairs (as well as unnecessary fiber deformation), leading to higher insertion loss. These problems are compounded in stacked configurations such as those shown in U.S. Patent Nos. 3,864,018, 4,046,454 and 4,865,413.

These difficulties may be avoided by the use of a substrate which is malleable, elastomeric or ductile. Unfortunately, however, the use of such materials has not been fully appreciated nor implemented. For example, U.S. Patent No. 4,046,454 teaches that the rigid V-grooves may be lined with a ductile material. This complicates the manufacturing process, however, and adds significant cost. In U.S. Patent No. 4,102,561, the splice device utilizes two alignment members formed of a resilient material which may deform against the fiber surfaces. That splice, however, requires the attachment of two subassemblies prior to insertion of the fibers into the alignment members, and further uses about a dozen clamps and bolts, making the device very difficult to use in the field (similar problems apply to the device illustrated in U.S. Patent No. 4,045,121). The primary clamping action directly at the fiber interface also causes deformation of the fiber resulting in more signal loss than if there were a more gradual clamping toward the interface. This problem also applies to other splice designs, such as that depicted in European Patent Application No. 88303777.2, which further suffers from the non-uniform application of clamping forces to different fibers.

In light of the foregoing, it would be desirable and advantageous to devise a high performance

-4-

splice device for multiple optical fibers which does not require fusion welding, or adhesives and polishing. The device should provide a uniform clamping force to each of the fibers, and provide gradual clamping to minimize undesirable deformations such as microbending at the clamp transition. The cleave length of the fibers should not be critical, and means should be provided to optimize fiber alignment, including the use of ductile clamping surfaces. Finally, the splice should be simple to use, especially for field installation.

Summary of the Invention

The foregoing objectives are achieved in a device for splicing multiple optical fibers comprising a splice element, a body surrounding the splice element, and a wedge providing uniform, transverse clamping of the fibers in the splice element. The body may be comprised of a jacket portion and a cap portion which interlock to hold the splice element. The splice element is preferably formed of a ductile material, and is hinged to define two plates, one plate having a series of parallel V-grooves, and the plates being folded together prior to actuation by the wedge. Stop pads are interposed between the plates to insure gradual clamping when the wedge is forcibly urged against the plates or against a tongue which is interposed between the plates and the wedge. The splice element may further have an extension or porch, with a ramp to facilitate insertion of the fibers into the splice element.

A stacked splice element may be provided in the body having more than two plates, e.g., a three-plate stack accommodating two layers of fiber splices. Special guides positioned at each end of the plates may be used to direct some fibers upward to one splice layer and others downward to the other layer. End covers are provided to protect the splice element and exposed fibers, and to provide an environmental seal.

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-5-

Brief Description of the Drawings

The novel features and scope of the invention are set forth in the appended claims. The invention itself, however, will best be understood by reference to
5 the accompanying drawings, wherein:

Figure 1 is a perspective view of the multiple optical splice device of the present invention;

Figure 2 is an exploded perspective view of the splice device of the present invention;

10 Figure 3 is a perspective view of the splice element used in the multiple fiber splice device of the present invention, in its unfolded state;

Figure 4 is an enlarged sectional perspective of one end of the splice element of Figure 3 showing the
15 porch and ramp;

Figure 5 is a sectional perspective view of the fully assembled splice device of the present invention;

Figure 6 is a sectional elevation of an alternative end cover used with the splice device of the
20 present invention, having a compartment therein for index matching gel; and

Figure 7 is a perspective view of the stacked splice embodiment of the present invention.

25 Description of the Preferred Embodiment

With reference now to the figures, and in particular with reference to Figure 1, there is depicted the multiple optical fiber splice device 10 of the present invention. Although the term "connector" may be
30 applied to splice 10, that term is usually reserved for devices which are intended to provide easy connection and disconnection, as opposed to a splice which is usually considered permanent. Nevertheless, the term "splice" should not be construed in a limiting sense since splice
35 10 can indeed allow removal of the fibers, as explained further below.

With further reference to Figure 2, splice 10



includes a generally rectangular body 12 which is essentially comprised of a jacket 14 and a cap 16. Splice 10 also includes a splice element 18 and longitudinal actuation means 20 for applying pressure to splice element 18. In the preferred embodiment, actuation means 20 comprises a wedge 22 having surfaces defining an acute angle, which is captured between jacket 14 and cap 16. A tongue 24, which is integrally molded with cap 16, is advantageously interposed between wedge 22 and splice element 18 as discussed further below. Jacket 14 has a longitudinal slot 26, rectangular in cross-section and extending through jacket 14, for receiving a splice element 18; slot 26 is slightly shorter than splice element 18, allowing both ends of element 18 to extend beyond the ends of slot 26. Jacket 14 also has an integrally molded male coupling element or projection 28 which fits within a cavity 30 formed in cap 16. Projection 28 has two transverse bumps 32 which snap into recesses 34 of cap 16, providing a snug fit between jacket 14 and cap 16.

Jacket 14 and cap 16 each have extensions 36 and 38, respectively, which receive end covers 40 and 42, respectively. Extensions 36 and 38 have recessed surfaces which support the fibers at the entrance to slot 26. End covers 40 and 42 impart protection to the spliced fibers and splice element 18 against environmental influences. End covers 40 and 42 are attached to extensions 36 and 38 of the jacket and cap, respectively, by any convenient means, such as arcuate jaws 44 which snap onto and rotatably grip trunnions 46. The side edges 48 of extensions 36 and 38 are rounded to allow end covers 40 and 42 to rotate on trunnions 46. End covers 40 and 42 also include hooks forming latches 50 which snap into notches 52 in extensions 36 and 38 and securely maintain the end covers in a tightly closed position.

Jacket 14 and cap 16 define many overlapping



surfaces which impart additional environmental sealing and further inhibit separation of these two components of body 12 by, e.g., bending of body 12. For example, projection 28 has a lower tier 54 which slides under a canopy 56 formed on cap 16. Cap 16 also includes bosses 58 which fit into recesses (not visible in the Figures) in the corresponding face of jacket 14. Projection 28 and cap 16 further have inclined surfaces 60 and 62 which result in a greater contact surface area and make it more difficult to pop jacket 14 and cap 16 apart by bending them near their interface.

Turning now to Figures 3 and 4, splice element 18 is described in further detail. Splice element 18 may be formed from a sheet of deformable material, preferably a ductile metal such as aluminum, although polymeric materials may also be used. Material selection is described further below. Certain features are embossed, coined, stamped, molded or milled into element 18. First of all, a groove 70 is formed on the outside surface 72 of element 18. Groove 70 forms an area of reduced thickness to define a bend line or hinge, and separates element 18 into two legs or plates 74 and 76 having essentially the same width. The hinge is preferably formed by additionally embossing a notch 78, opposite groove 70, on the inside surface 80 of element. This creates a "focus hinge" which provides more accurate registration of plates 74 and 76 when they are folded together, as explained further below. A slot 81 may also be punched out of element 18 to facilitate folding.

In one embodiment of the present invention, plate 76 has a series of V-shaped grooves 82 embossed on the inside surface 80 of element 18. V-grooves 82 are generally parallel with groove 70. Those skilled in the art will appreciate that the V-grooves may instead be formed in plate 74, or in both plates, and further that the shape of the grooves is not limited to a "V" cross-section. Nevertheless, in the preferred embodiment only



one of the plates has grooves therein, and these are V-shaped having an interior angle of about 60°. In this manner, when a fiber is placed in one of the grooves and clamped by surface 80 of plate 74, the points of contact
5 between element 18 and the fiber generally form an equilateral triangle which minimizes transverse offset and thus reduces signal loss in the splice.

Plate 74 is further distinguished from plate 76 in that plate 74 has extensions or porches 84 which also
10 have grooves 86 therein, although grooves 86 do not extend the full length of plate 74. Grooves 86 are also wider than V-grooves 82 since it is intended that the portion of the fibers lying on porches 84 will still have their buffer coating, but this coating is stripped from
15 the fiber ends which are clamped between plate 74 and V-grooves 82 (i.e., the buffered portions of the fiber have a larger diameter than the exposed portions). Grooves 86 are further recessed in surface 80, and are adjacent to ramps 88 leading up to surface 80, as more clearly seen
20 in Figure 4. Ramps 88 eliminate microbending (which causes further signal loss) which would result if the buffered portion of the fiber and the exposed portion were to lie in the same plane. In other words, the transition from buffered fiber to exposed fiber occurs
25 proximate ramps 88. Accordingly, the height of ramps 88 is approximately equal to the thickness of the buffer surrounding the fiber. Ramps 88 may be formed in porch areas 84 although they are preferably formed in plate 74 whereby they lie under plate 76 when the plates are
30 folded together. Recesses (not shown) may optionally be provided in extensions 36 and 38, under porches 84, to allow the porches to be flexed slightly downward, which further facilitates insertion of the fibers into splice element 18 and reduces potential skiving along grooves
35 86.

The number of V-grooves 82 and 86 in splice element 18 is variable, depending upon the desired



-9-

application. Grooves 86 should be aligned with V-grooves 82 when splice element 18 is folded, to insure proper positioning of the fibers during the clamping operation. Thus, while registration of plates 74 and 76 is not as critical as with some prior art splice devices (since there are no V-grooves on plate 74 which directly oppose V-grooves 82) it is still beneficial to use the aforementioned focus hinge in order to optimize the alignment of grooves 82 and 86.

In the stamping process which creates splice element 18, stop pads 90 are also advantageously formed on both plates 74 and 76 at the corners of the rectangle defined by the overlap of the plates. These pads are slightly raised with respect to the otherwise flat inside surface 80 of element 18. In this manner, when element 18 is folded as in Figure 1, stop pads 90 provide a clearance space between plates 74 and 76, facilitating insertion of the fibers therebetween. Alternative methods of providing such a clearance space will become apparent to those skilled in the art. More importantly, however, stop pads 90 insure that, when element 18 is actuated and clamps the fibers, the maximum clamping force is exerted only along the central width of element 18, and the clamping force gradually decreases moving from the center toward the ends of element 18. This gradual clamping transition has been found to significantly reduce signal loss resulting from the deformation of the fibers, i.e., prior art splice devices exhibited an abrupt clamping deformation which induced higher losses.

Assembly and operation of splice 10 are both straightforward and may best be understood with reference to Figure 5. Splice element 18 is placed in slot 26 in a folded state; in this state, clearance is still provided by stop pads 90 to allow insertion of the fibers, so this may be considered an open state, as opposed to the closed, clamping state. An index matching gel is



-10-

preferably deposited near the center of element 18. Wedge 22 is then placed adjacent tongue 24, and jacket 14 is snapped into cap 16, whereupon wedge 22 becomes disposed against another ramp 92 formed in the lower portion of jacket 14. The upper surface of wedge 22 is generally parallel with plates 74 and 76, while the lower surface of wedge 22 is parallel with ramp 92. Tongue 24 is further supported at its distal end by a shelf 94 formed in the lower portion of jacket 14, above ramp 92. End covers 40 and 42 may be attached to extensions 36 and 38 at any time in the assembly process (although they are not snapped into the closed position until after the fibers have been spliced). All of the foregoing steps take place in the factory, and splice 10 is provided to the user in the state shown in Figure 1 (less the fiber ribbon).

When the user has located the fibers to be spliced, they should be stripped and cleaved according to well-known methods. In this regard, splice 10 may be used to splice the fiber ribbons 96a and 96b shown in Figure 1, or may be used to splice a plurality of individual, discrete fibers. Such discrete fibers may be more conveniently handled by first arranging them side-by-side and applying a piece of tape or other means to effectively create a fiber ribbon. If fiber ribbon is being spliced, the outer coating which surrounds the individual buffered fibers should also be removed.

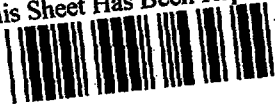
Once the fibers or ribbons have been inserted into body 12, splice 10 may be actuated by longitudinally sliding wedge 22 toward jacket 14. In this regard, the term "longitudinal" refers to movement parallel with the fibers and grooves 82. The sliding action may be accomplished by simply using a screwdriver or other tool to push wedge 22 forward. The screwdriver may be applied to the cutout 98 formed in wedge 22. As wedge 22 moves forward onto ramp 92, it causes tongue 24 to press against the outer surface of plate 74, clamping the



-11-

fibers between plates 74 and 76. The width of tongue 24 is approximately equal to the width of plates 74 and 76. As discussed above, the clamping forces gradually decreases towards the ends of splice element 18 due to stop pads 90. This effect may be enhanced by making the lengths of wedge 22 and tongue 24 shorter than the length of plates 74 and 76 so that the clamping force is applied primarily at the center of splice element 18, and not at its ends. In the preferred embodiment, the length of that portion of wedge 22 contacting tongue 24 is about one-half the length of plate 76. The use of tongue 24 also prevents undue deformation of plate 74 which might otherwise occur if wedge 22 were to contact splice element 18 directly. Wedge 22 provides excellent mechanical advantages, including high transmission of forces, and the uniform application of force parallel to plates 74 and 76. Also, due to the coefficient of friction of the materials used for jacket 14, wedge 22 and tongue 24, actuation means 20 (i.e., wedge 22) is self-locking, provided it has an angle of less than about 9°. The preferred angle is about 5°. Simplicity in the use of splice 10 is evident from a summary of the above steps: stripping and cleaving the fibers, inserting them into body 12, and sliding wedge 22 forward. A double wedge (not shown) may be used in lieu of single wedge 22.

After the splice is completed, end covers 40 and 42 may be moved to the closed, latched position to provide environmental sealing and protect the exposed fibers. In this regard, legs 100 of the end covers, which rest on stage areas 102 of porches 84, help keep the fiber ribbon aligned with splice body 12, i.e., they oppose sideways bending of the ribbon proximate the entrance to slot 26. Legs 100 also provide additional sealing of slot 26 since they are positioned at the sides thereof. Although not designed for disconnection and reconnection, splice 10 may allow removal of fibers by simply opening end covers 40 and sliding wedge 22 backward.



-12-

Several different materials may be used in the construction of splice 10. Splice element 18 may be constructed from a variety of ductile metals, such as soft aluminum. The preferred metal is an aluminum alloy conventionally known as "3003," having a temper of 0 and a hardness on the Brinnell scale (BHN) of between 23 and 32. Another acceptable alloy is referred to as "1100," and has a temper of 0, H14 or H15. Acceptable tensile strengths vary from 35 to 115 megapascals.

Other metals and alloys, or laminates thereof, may be used in the construction of splice element 18. Such metals include copper, tin, zinc, lead, indium, gold and alloys thereof. It may be desirable to provide a transparent splicing element to facilitate the splicing operation. In such a case, a clear polymeric material may be used. Suitable polymers include polyethylene terephthalate, polyethylene terephthalate glycol, acetate, polycarbonate, polyethersulfone, polyetheretherketone, polyetherimide, polyvinylidene fluoride, polysulfone, and copolyesters such as Vivak (a trademark of Sheffield Plastics, Inc., of Sheffield, Massachusetts).

As an alternative to providing a splice element constructed of a deformable material, it may instead be formed of a more rigid material provided that V-grooves 82 and/or surface 80 are lined with a deformable material. The primary requisite is to provide a material which is softer than the glass comprising the optical fiber and cladding, and which is ductile under the clamping pressures applied to the optical fiber. It is also desirable that the material be elastic at low stress levels to afford sufficient elasticity to maintain a continual compressive force on the optical fibers once plates 74 and 76 have been brought together.

Furthermore, a coating may be applied to the ductile material to reduce skiving of the material as the fiber is inserted. For example, a diamond-like carbon coating



-13-

having a thickness in the range of 0.1 to 0.4 μm may be applied to surface 80 of splice element 18 by vapor deposition.

5 Splice body 12 may also be constructed of a variety of materials, basically any durable material and preferably one that is injection moldable, although die cast metals are acceptable. The material should not be too rigid as it is desirable to allow the inner walls forming slot 26 to flex slightly to store excess clamping forces from wedge 22 in order to insure constant clamping force on the fibers during temperature cycling.

10 Injection moldable materials include liquid crystal polymer, such as that sold under the trademark VECTRA A130 by Hoechst Celanese Corp. of Summit, New Jersey.

15 The dimensions of splice 10 may vary widely according to the desired application. The following (approximate) dimensions, for the preferred embodiment, are exemplary only and should not be construed in a limiting sense. The overall length of splice 10 is 38 mm, its height 6.7 mm and its width 13 mm. The length of the main portion of jacket 14 is 14 mm, while projection 28 is about 7.1 mm long and 9.7 mm wide. Cap 14 is 7.6 mm long, and extensions 36 and 38 are each 8.3 mm long. Wedge 22 has an overall length of 14 mm, but the length of the portion contacting tongue 24 is 10 mm. The width of wedge 22 is 6.5 mm, while its maximum thickness is 1.5 mm and its minimum thickness is 0.76 mm.

20 With respect to splice element 18, several of the following approximate dimensions are based on the size of conventional multiple fiber ribbon cables. The length of plate 74 (including porches 84) is 28 mm, while the length of plate 76 is 20 mm. Both plates have a thickness of 530 μm , and stop pads 90 rise 18 μm above surface 80. V-grooves 82, preferably spaced 250 μm apart, are 130 μm deep and have a maximum width of 180 μm . Grooves 86, which are approximately trapezoidal in the preferred embodiment, also have a maximum width of



-14-

180 μm , and a minimum width of 120 μm , and are 180 μm deep. Ramp 88 descends 250 μm , i.e., the upper surfaces of grooves 86 are 250 μm from surface 80.

Two alternative embodiments and design

5 modifications are shown in Figures 6 and 7. Figure 6 illustrates a modified end cover 42' which may be used on both jacket extension 36 and cap extension 38. End cover 42' is used to provide additional environmental sealing, by means of a compartment 104 defined by a wall 106 which
10 is attached to the inner surface of cover 42' by a living hinge 108. As end cover 42' is closed, wall 106 contacts extension 38, causing wall 106 to compress a sealant material, which may include index matching gel, residing in compartment 106. Wall 106 has channels 110 therein
15 which allow the sealant to escape from compartment 104, and flow in and around the entrance to slot 26. A web 112 is preferably integrally formed with wall 106, extending into compartment 104, which assures that sealant will be directed out of channels 110 when cover
20 42' is closed, and also provides resistance against such closure to prevent accidental leakage of the sealant.

Figure 7 depicts a stacked splice device 10' which utilizes a splice element 18' having two layers of splices. Stacked splice element 18' may be formed of
25 three separate elements, but it is preferably constructed of a single element having two integral hinges, folded into a Z-shape (accordion-fold). In this manner, the three sections of the sheet defined by the hinges result in three different plates 114, 115 and 116. It is not
30 necessary that the two splice layers formed thereby be parallel, but this is preferred to simplify the wedge actuation. An alternative construction would provide a single sheet of material having two parallel hinges separated by a small distance, e.g., 50 μm , forming the
35 upper and lower plates, with a third plate inserted therebetween. A plug 118 having two sets of orifices 124 is advantageously used to guide a first set of fibers,

-15-

i.e., every other fiber, upwards to the top splice layer, and the remaining fibers downwards to the bottom splice layer. Guide plug 118 has grooves 120 formed in a porch area 122 thereof, similar to porch 84 of element 18; 5 grooves 120 help align the fibers with orifices 124. Of course, the use of an accordion fold and guide plug could be expanded to splice elements having more than two splice layers.

Although the invention has been described with 10 reference to specific embodiments, this description is not meant to be construed in a limiting sense. Various modifications of the disclosed embodiment, as well as alternative embodiments of the invention, will become apparent to persons skilled in the art upon reference to 15 the description of the invention. For example, a multiple fiber splice device may be constructed to allow separate termination of each fiber set by providing two actuation wedges, one at each end of splice body 12; this would allow the pretermination of one fiber set in the 20 clamped state. It is therefore contemplated that such modifications can be made without departing from the spirit or scope of the present invention as defined in the appended claims.

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-16-

I claim:

1. An element for splicing a first plurality of optical fibers to a second plurality of optical fibers, the element comprising:

5 first and second plate members forming a pair of opposing surfaces, at least one of said opposing surfaces of said first and second plate members having a plurality of fiber receiving grooves therein; and

10 first and second porch members attached to first and second ends, respectively, of said first plate member, said first and second porch members extending beyond first and second ends of said second plate member, respectively, said first and second porch members having surfaces which have guide grooves formed therein, said
15 guide grooves being aligned with said fiber receiving grooves.

2. The element of Claim 1 wherein said first and second plate members are formed from a single sheet of ductile material having a fold line therein forming a
20 hinge.

3. The element of Claim 1 wherein said opposing surfaces are formed of a ductile material.

4. The element of Claim 1 wherein said fiber receiving grooves are formed in said opposing surface of
25 said second plate member.

5. The element of Claim 1 for use with fibers having a buffered portion and an exposed portion, wherein said first and second ends of said first plate member include ramp means for supporting the fibers proximate a
30 transition between the buffered and exposed portions of the fibers, said guide grooves being adjacent said ramp means.

6. The element of Claim 1 wherein at least one of said first and second plate members includes means
35 providing a clearance space between said opposing surfaces at said first and second ends of said first and second plate members.

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-17-

7. The element of Claim 1 further comprising a third plate member adjacent said second plate member, forming a second pair of opposing surfaces, at least one of said surfaces in said second pair having a second plurality of fiber receiving grooves therein.

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8. The element of Claim 5 wherein the buffered portions of the fibers have a buffer coating of known thickness, and:

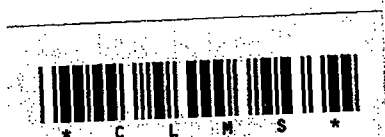
said first and second porch members are integrally formed with said first and second ends of said first plate member, respectively;

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said guide grooves are recessed in said surfaces of said porch members; and

said ramp means comprises a ramped surface extending from said recessed guide grooves to said opposing surface of said first plate member, said ramped surface having a height which is approximately equal to the thickness of the buffer coating.

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-18-

9. An element for splicing a first plurality of optical fibers to a second plurality of optical fibers, the element comprising:

5 first and second plate members forming a pair of opposing surfaces each having first and second ends, at least one of said surfaces having a plurality of fiber receiving grooves therein; and

clearance means for providing a space between said opposing surfaces at said first and second ends
10 thereof whereby, when said opposing surfaces are clamped toward one another, a higher clamping force is applied at a center of the element than at said first and second ends thereof.

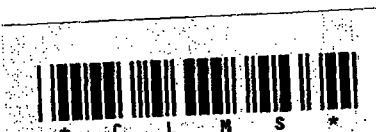
10. The element of Claim 9 wherein said first
15 and second plate members are formed from a single sheet of ductile material having a fold line therein forming a hinge.

11. The element of Claim 9 wherein said
20 clearance means comprises a plurality of pads attached to said opposing surface of said first plate member at said first and second ends thereof.

12. The element of Claim 9 intended for use
with fibers having a buffered portion, the element
further including a porch area having ramp means for
25 receiving the buffered portion of the fibers, said ramp means including guide grooves which are generally aligned with said splice grooves.

13. The element of Claim 9 further comprising a
third plate member adjacent said second plate member,
30 forming a second pair of opposing surfaces, at least one of said surfaces in said second pair having a second plurality of fiber receiving grooves therein.

14. The element of Claim 11 wherein said first
plate member has a generally rectangular shape defining
35 four corners, and said opposing surface of said first plate member has four pads integrally formed thereon, one pad at each of said corners.





-19-

15. An element for splicing a first plurality of optical fibers to a second plurality of optical fibers, the element comprising:

5 first and second plate members, defining a first pair of opposing surfaces, both of said surfaces of said first pair being ductile and at least one of said surfaces of said first pair having a first plurality of fiber receiving grooves therein; and

10 a third plate member, said second and third plate members defining a second pair of opposing surfaces, both of said surfaces of said second pair being ductile and at least one of said surfaces of said second pair having a second plurality of fiber receiving grooves therein, and at least two of said first, second and third
15 plate members being formed from a single sheet of ductile material having a fold line forming a hinge.

16. The element of Claim 15 further comprising means for guiding a first set of the first plurality of optical fibers to said first plurality of fiber receiving
20 grooves and for guiding a second set of the first plurality of optical fibers to said second plurality of fiber receiving grooves.

17. The element of Claim 15 wherein said first, second and third plate members are all formed from a
25 single sheet of ductile material, said sheet having two fold lines forming hinges and being folded in a Z-shape.

18. The element of Claim 15 wherein said first plate member has first and second ends, and includes means providing a clearance space between said first pair
30 of opposing surfaces at said first and second ends.

19. The element of Claim 16 wherein said guiding means comprises a plug adjacent a first end of said first, second and third plate members, said plug having a first set of orifices directed toward said first
35 plurality of fiber receiving grooves, and a second set of orifices directed toward said second plurality of fiber receiving grooves.

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-20-

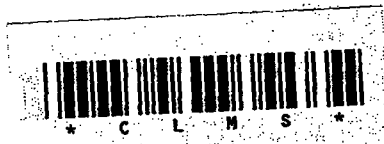
20. An element for splicing a first plurality of optical fibers to a second plurality of optical fibers, the element comprising:

5 a first generally rectangular plate having first and second ends, and four corners, and further having ramped surfaces at said first and second ends;

10 first and second porches attached to and integral with said first and second ends, respectively, of said first plate, said porches having a plurality of recessed guide grooves immediately adjacent said ramped surfaces;

15 a second generally rectangular plate approximately equal in size to said first plate, said first and second plates being formed from a single sheet of ductile material having a fold line forming a hinge, said first and second plates being folded toward one another, defining an opposing surface of said second plate, said opposing surface having a plurality of fiber receiving grooves therein, aligned with said guide
20 grooves in said porches and generally parallel with said fold line; and

at least four pads integrally formed on said first plate, one pad at each of said corners.



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